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The effect of graduate education on promotion of U.S. Army field grade officer by career field

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THESIS

THE EFFECT OF GRADUATE EDUCATION ON PROMOTION OF U.S. ARMY FIELD GRADE OFFICER BY CAREER FIELD

by

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March 2008

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The probit estimations indicate that the effect of graduate education for a representative officer increase the promotion probabilities by 0.148 and 0.132 for the grades of Lieutenant Colonel and Colonel, respectively. After correcting for sample selection bias, the effect of graduate education on the promotion to Lieutenant Colonel is reduced by 59.5 percent. After correction for endogeneity, this effect is increased by 70.9 percent. Finally, this effect increases by 61.5 percent after correction for both sample selection bias and endogeneity.

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THE EFFECT OF GRADUATE EDUCATION ON PROMOTION OF U.S. ARMY FIELD GRADE OFFICER BY CAREER FIELD

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ACKNOWLEDGMENTS

"… Then you will know the truth, and the truth will set you free."

John 8:32

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I. INTRODUCTION

A. BACKGROUND OF STUDY

Military officers who served and fought for their countries in ancient or medieval times did not necessarily need to have an advanced education to be successful officers or winners of battles. However, the current war environment requires officers to not only be disciplined and physically fit for war, but also to be technically fit for the a war of technology and information. They should think critically and analytically to win the war. For that reason, nowadays many armed forces throughout the world educate their officers at civilian and military academic institutions so that they can receive graduate degrees such as Master's degrees or Doctorate degrees. The United States Army also encourages officers to obtain their graduate education and supports them with fully-, or partially-funded programs. Also, several officers have either earned or are willing to earn their graduate degree by self-funding.

Since an investment in human capital increases an officer's productivity according to human capital theory, officers who already have a graduate degree should be more productive compared to officers without a graduate degree. Unlike a civilian company, a person's productivity can not be easily measured by an index such as wage differential. Gibbs points out characteristics of federal pay systems compared to those of private sector by noting that "federal pay systems are even more centralized, simple, and rigid in structure."[1] Also, he discusses in respect to rigidity and raises of DoD civilian compensation in General Schedule (GS) system that "Raises were awarded primarily for seniority so that pay for performance came about chiefly through promotions."[2] Since characteristics of military compensation system are similar to that of GS system in respect to rigidity, outcomes of promotion selection can be considered a good

[1] Gibbs, Returns to Skills and Personnel Management, 213.

[2] Ibid., 202.

measurement for individual productivity or performance. Wise also argued that promotion is proper measurement of performance if a certain hierarchical organization promotes higher performers faster than lower performers.[3] Furthermore, the promotion of the officer is one of the most objective and reliable indexes for measuring an officer's productivity in the military environment.

Several studies have already been conducted to measure and isolate the effect of a graduate education on the promotion of officers. Causal effects, however, are prone to biases from self-selection or attrition and endogeneity of graduate education. Also, the effect of graduate education depends largely on career fields because field officers in U.S. Army are uniquely and separately managed by the Officers Personnel Management System (OPMS).

B. PURPOSE OF STUDY AND RESEARCH QUESTION

The purpose of this study is to estimate unbiased effect of a graduate education on the promotion of an U.S. Army field grade officer. The effect of a graduate education can be under or over estimated because of sample selection bias or endogeneity. Since field grade officers are assigned, managed, and promoted by each career field of OPMS, estimation should be conducted for each of the four career fields of OPMS, separately.

Following is the primary question of this study:

1. What is the unbiased effect of a graduate education on the promotion of U.S. Army field grade officers?

These are the secondary questions:

1. Is the effect of a graduate education significantly different for each career field?

2. Are there any other factors that interact with education that have a noteworthy effect on promotions?

[3] Wise, Personal Attributes, Job Performance, and Probability of Promotion, 913.

C. SCOPE AND ORGANIZATION OF STUDY

This study will investigate the effect of a graduate education on the promotion of U.S. Army field grade officers. More specifically, the study will focus on the effects of a graduate education on the promotion to Lieutenant Colonel and Colonel. Furthermore, the effects will be separately analyzed by the four career fields of the U.S. Army. These career fields are Operations, Information Operations, Institutional Support, and Operational Support.[4]

Chapter II discusses general theories and several related prior studies so that a logical model for estimating the effect of education can be built. Also, the study looks at promotion, education, and OPMS of the U.S. Army. Chapter III presents a summary of the data and introduces dependent and independent variables. In addition, chapter III introduces methodologies and models used for the analysis. Then, chapter IV will present the results of several estimations. Finally, chapter V discusses conclusions and recommendations based upon the estimated results in Chapter VI.

D. METHODOLOGY

The study is primarily quantitative and based upon data from U.S. Army Officer Active Duty Master file cohorts from 1981 through 2001. The data is provided by the Defense Manpower Data Center (DMDC). The methodology used in this study consists of the following steps:

1. Review of human capital theory, promotion policy, and OPMS of the U.S. Army.
2. Review of previous studies in regards to the effect of a graduate education.
3. Build a multivariate model based upon literature review.
4. Conduct a multivariate analysis of the full sample using simple probit regression, as well as analysis of the four separate career fields.

[4] Headquarters Department of Army, *Commissioned Officer Professional Development and Career Management,* 52.

5. Perform a correction procedure using the Heckit method to correct for sample selection bias due to attrition.
6. Perform a correction procedure using instrumental variables to correct for endogeneity due to self-selection.
7. Perform a correction procedure using a double selection model for biases because the initial models will likely be prone to both sample selection bias and endogeneity.
8. Interpret and discuss estimation results, draw conclusions from results and offer recommendations for further study.

E. CHAPTER SUMMARY

A graduate education increases an individual's productivity according to human capital theory. The U.S. Army also encourages officers to obtain graduate degrees. Increased productivity of the individual officer can be measured by promotion data in the military environment. Several estimations will be conducted to measure and isolate the unbiased effect of a graduate education on the promotion of U.S. Army field grade officers by career field by OPMS.

II. BACKGROUND

A. HUMAN CAPITAL THEORY

The human capital theory developed by Becker (1975) posits that investments in human capital increase the productivity of individuals and therefore increase earnings.[5] Schultz points out that education and health programs, as well as internal migration, are examples of the investment in human capital.[6] In his study, he focuses on spending special attention to education and training, especially a graduate education.

Becker distinguishes between general training and specific training. General training is defined as training that "increases the marginal productivity of trainees by exactly the same amount in the firms providing the training as in other firms."[7] Education would be an example of general human capital, since it enhances the general skills and productivity of individuals in any firm. On the other hand, specific training only increases the productivity of the individual in the employing firm.[8] Such training would involve skills that are too specific to carry over to other firms. Labor theory suggests that firms want to sponsor specific training, but not general training because the latter makes individuals more marketable and may increase attrition. In the civilian sector, employers will invest in training for employees only if the post-training marginal productivity exceeds increased wages and costs of training.[9] In the public sectors, policy-makers need to investigate the policy of sponsoring advanced degrees and justify the cost based upon estimated rates of return and a conduct cost-benefit analysis.[10]

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[5] Becker, *Human Capital*, 231.

[6] Schultz, *Investment in Human Capital*, 24-25.

[7] Becker, *Human Capital*, 13-14.

[8] Ibid.

[9] Ehrenberg and Smith, *Modern Labor Economics*, 157.

[10] Ibid., 308.

The U.S. Army also provides both general and specific training to its enlistees and officers. The U.S. Army officers are encouraged to obtain a graduate education. The Army funds graduate education programs in full or partially. These programs can increase the productivity and also can be used as an incentive for recruiting. Also, these programs are used as a tool for officer retention. However, they may increase employment opportunities outside and indirectly affect attrition.

B. MILITARY AS AN INTERNAL LABOR MARKET

Doeringer and Piore argue that "The internal labor market, governed by administrative rules, is to be distinguished from the *external labor market* of conventional economic theory where pricing, allocating, and training decisions are controlled directly by economic variables."[11] The military can also be viewed as an internal labor market from the perspective of labor economists. According to Asch and Warner, military as an internal labor market has unique characteristics such as a vertical hierarchy with a closed personnel system.[12]

Bowman and Mehay adopt this approach to analyze the United States Navy (USN) and the effect of graduate education on careers.[13] In this paper I investigate the same question focusing on the U.S. Army. The U.S. Army is organized as a vertical hierarchy made of ranks and its personnel system is also closed and well-defined by OPMS. It seldom allows lateral entry and involves the up-or-out system. Therefore, theses unique characteristics as an internal labor market should be considered in the process of analysis.

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[11] Doeringer and Piore, *Internal Labor Markets and Manpower*, 2.

[12] Asch and Warner, *A Theory of Military Compensation and Personnel Policy*, 37-38.

[13] Bowman and Mehay, Graduate education and employee performance.

C. OFFICER EDUCATION SYSTEM IN THE U.S. ARMY

The U.S. Army defines its strategic goal of Officer Education System (OES) transformation as "to create an education and training system operationally relevant to the current force, but structured to support the Future Force by producing more capable, adaptable and confident leaders through continuous investment in personal growth and professional development throughout their careers."[14] Its strategic goal is well-aligned with human capital theory. A graduate education is also one of the categories of the U.S. Army OES.

Officers are encouraged to get advanced degrees[15] when they are available via the use of fully- or partially-funded programs.[16] Normally to be selected for these programs, an officer should have finished his or her Captains Career Course (CCC) which is offered to officer who is promoted to Captain in the Army. The CCC should be completed before a Captain commands a company level unit. And they should have sufficient experience regarding branch or Military Occupational Specialty (MOS) to be selected for the programs.[17] Under fully-funded programs, an officer will receive the costs of tuition, textbooks, and supplies for an 18-month study period.[18] Under partially-funded programs, an officer should pay for all tuition, fees, and books except the full pay, allowance, and moves.[19]

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[14] Headquarters Department of Army, Commissioned Officer Professional Development and Career Management, 24.

[15] Master's or Doctoral degree.

[16] Ibid., 30-31.

[17] Headquarters Department of Army, *Commissioned Officer Professional Development and Career Management,* 31.

[18] Ibid., 31.

[19] Ibid., 31.

D. CAREER FIELD AND PROMOTION IN THE ARMY

OPMS governs the career management of company and field grade officers in the U.S. Army. It is implemented by the U.S. Army Human Resource Command (HRC) Officer Personnel Management Directorate (OPMD).[20] Its missions are to

1. Access and designate officers in the right numbers and with the right skills to satisfy current and projected Army requirements.
2. Develop the professional skills and Warrior Ethos of officers through planned schooling and sequential, progressive assignments.
3. Assign officers to meet Army requirements.
4. Separate officers to meet individual and Army needs.[21]

The subsystems of OPMS are strength management, career development, evaluation, and centralized selection. According to the Army Regulation 600-3, the key concept of OPMS is career field-based management.[22] An officer who is promoted to major or O4 level is designated to one of four OPMS career fields by the Career Field Designation Board (CFDB). The four career fields consist of 39 branches and 19 functional areas (FA). The field grade officer's career patterns are managed mainly by a subsystem of OPMS. The U.S. Army revised OPMS career fields designated by the new OPMD design in 2005. The new career branches are: Maneuver, Fires and Effects (MFE); Operations Support (OS); and Force Sustainment (FS).[23] This study will focus and analyze data using the former OPMS design because the dataset used for analysis is comprised of U.S. Army Officer cohorts from 1981 to 1985. These cohorts are reviewed and selected under former OPMS design by the promotion selection board.

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[20] Headquarters Department of Army, *Commissioned Officer Professional Development and Career Management,* 10.

[21] Ibid., 10.

[22] Ibid., 14.

[23] The U.S. Army Human Resource Command webpage, Officer Personnel Management Directorate.

U.S. Army officer selection for promotions from Major to Colonel is conducted by the Headquarters, Department of Army (HQDA) centralized board.[24] For the selection, the centralized board considers the following factors:

(1) Performance

(2) Embodiment of Army values

(3) Professional attributes and ethics

(4) Integrity and character

(5) Assignment history and professional development

(6) Military bearing and physical fitness

(7) Attitude, dedication, and service

(8) Military and civilian education and training

(9) Concern for soldiers and families[25]

Table 1 shows promotion opportunities and time requirements to be promoted to next higher rank from First Lieutenant to Colonel. In this study I focus on the promotions to Lieutenant Colonel and Colonel. To be reviewed for the selection of promotion to Lieutenant Colonel, an officer should have served at least fifteen years in the Army and at least three years as a Major. For the promotion to Colonel, an officer should have served at least twenty one years in the Army and at least three years as a Lieutenant Colonel (refer to Table 1).

Table 1. Time in Service (TIS), Time in Grade (TIG), and Promotion opportunity

Promote to:	Timing (TIS)	TIG	Promotion Opportunity
1LT/O2	18 months	18 months	fully qualified
CPT/O3	4 years plus 1 year	2 years	best qualified (90%)
MAJ/O4	10 years +/- 1 year	3 years	best qualified (80%)
LTC/O5	16 years +/- 1 year	3 years	best qualified (70%)
COL/O6	22 years +/- 1 year	3 years	best qualified (50%)

Source: From Headquarters Department of Army, Commissioned Officer Professional Development and Career Management (2005), table 5-2, p. 35.

[24] Headquarters Department of Army, *Commissioned Officer Professional Development and Career Management,* 35-36.

[25] Ibid., 36.

E. REVIEW OF PREVIOUS STUDIES

In this section, I review previous studies that have investigated the return to graduate education to build logical multivariate model and correction model. Particularly, attention will be given to selection bias issues. Data sets used in this study are prone to two possible selection bias, sample selection bias and endogeneity. First, sample selection bias can be caused by incidental truncation of sample. Usually, the explanatory factors can always be observed for the estimation. However, the outcome variable which, in this study includes promotions, can not be observed when an officer leaves before being reviewed for promotion. If officers who left earlier are systematically different from officers who stayed, it can cause non-random sample selection issues and can result in biased estimators of the parameters. Thus, correction for sample selection bias is important to obtain unbiased effects of the graduate education variable. Second, the endogeneity problem can be caused by individuals selecting to enroll in graduate education. The officers who obtain a graduate degree may have higher cognitive ability, may have different preferences, and opportunity costs of attending graduate education programs. In this sense, the graduate education indicator may be an endogenous variable. This problem can also result in biased estimators of the parameters. Therefore, another correction for endogeneity is necessary in order to obtain the unbiased effect of the graduate education variable.

Previous studies have used data sets about employees in private sector, DoD civilians, Army, Navy, Marine Corps, and Air Force officers and adopted various approaches to conduct multivariate analysis and correct some possible biases. Bowman and Mehay conducted a correction method using bivariate probit approach to correct endogeneity of a graduate education variable. Instrumental variables used for correction include sub-specialties, preference for graduate school, and a college performance variable (other than GPA) such as college math and science background.[26] Branigan also employed correction methods for both sample selection and self-selection biases,

[26] Bowman and Mehay, Graduate education and employee performance.

separately. He used bivariate probit model and a two-step Heckman method for the corrections.[27] However, he did not attempt to correct for both biases simultaneously. Other studies reviewed in this section have not considered or discussed corrections for possible biases.

Blackburn and Neumark use data from the National Longitudinal Survey Youth 1979 (NLSY79) to examine the effect of omitted ability on schooling, and its effect on the wages of young workers.[28] Authors implemented instrumental variable regression using scores from the Armed Services Vocational Aptitude Battery (ASVAB) tests as proxies to correct for omitted ability bias in ordinary least-squares (OLS) wage equation.[29] They concluded that there is no evidence of causal relationship between ability-schooling relationship and upward bias of returns to education, and they also found that returns to education had been increased only for workers who possess higher academic ability.[30] In sum, their findings are generally consistent with human capital theory. Furthermore, they corrected omitted ability bias or endogeneity of education variable in wage equation.

Gibbs used data on DoD civilians to examine returns to skills for civilian scientists and engineers of U.S. DoD laboratories.[31] His data set included demographic, job, and compensation variables of DoD employees from fiscal year 1992 through 1996. He separately conducted analyses for three different DoD pay systems such as GS pay plan, Performance Management and Recognition System (PMRS), and Navy's pay plan at the Naval Weapons Center at China Lake, California. He built logit salary models to conduct multivariate analysis of returns to education. His explanatory variables include Master's degree, Doctorate degree, age, race, gender, veteran status, occupation, agency,

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[27] Branigan, *The Effect of Graduate Education on the Retention and Promotion of Marine Corps Officers*.

[28] Blackburn and Neumark, Omitted-Ability Bias and the Increase in the Return to Schooling.

[29] Ibid., 526.

[30] Ibid., 541.

[31] Gibbs, Returns to Skills and Personnel Management, 200.

region, and a quadratic for years of service. He found that the returns to graduate degrees stayed "flat or declined" for DoD civilian scientists and engineers in the GS and China Lake pay plan, whereas, pattern of PMRS pay plan is inconclusive.[32] Finally, he concluded that returns to education for GS and China Lake pay plan did not rise over the period compared to private sectors firm.[33] His findings are inconsistent with the theory of investments in human capital. He tried to make comparisons between private sector and public sector using various approaches such as analyses of recruitment and retention, and argued several possible explanations for his findings. One of the explanations is that there exist some variation in employees' quality due to "inflation in titles and salary grades."[34] Another explanation is that initial DoD compensation levels were higher than those of the private sector, and the private sector has closed the gap.[35] However, he did not consider sample selection and endogeneity issues. This is important to address because these issues can result in biased estimators. For example, if the advanced degree holders, who work for the government are systematically different from advanced degree holders who work in the civilian workplace, then it can cause sample selection problem.

Celik also conducted a multivariate study about the relationship between graduate education and the job performance of Department of Defense (DoD) civilian employees.[36] He focused on promotion speed and other selected job performance measures for all civilian DoD personnel employed between 1986 and 1999. He used two data sets including 213,482 observations from DMDC. Variables used for this study were sex, race, veteran status, agency, education, pay plan, supervisory status, and occupational category.[37] He estimated several models predicting salary, promotion, retention, and performance rating. Three different methodologies were used for the

[32] Gibbs, Returns to Skills and Personnel Management, 204-205.

[33] Ibid., 212.

[34] Ibid., 213.

[35] Ibid.

[36] Celik, *An Analysis of The Effect of Graduate Education on the Job Performance of Federal (DOD) Civilian Employees*, 1.

[37] Ibid., 30.

estimation of performance models. First, OLS was used to estimate the salary and performance rating models. Second, binary logit regressions were used to estimate promotion, retention, and performance rating models. Third, survival analysis using Cox Regression estimated the speed of promotion and the time to separation. The study found that employees with a Master's or Doctorate degree gained more and received higher salary increases in the service. He also found that employees with a graduate degree were promoted slower since they were placed at the higher general schedule grades at entry, which limited subsequent opportunities for promotion. Higher educated employees were also more likely to leave federal service, but were more likely to be evaluated as a top performer and be selected as a supervisor.[38] In general, his findings are consistent with human capital theory. The strength of this study is that the author tried to use various approaches to measure the effect of education on job performance. However, he did not address or correct for any other possible selection issues. For example, highly educated employees may have had higher ability and so higher performance could be attributed to ability not education. Also, since higher-ability individuals are more likely to leave, the promotion models may suffer from sample selection bias.

Pearson conducted a study to examine the relationship between a graduate education and job performance of U.S. Air Force (USAF) line officers.[39] Pearson particularly focused on the retention and promotion of USAF officers to the levels of Captain and Major. Also, he tried to investigate whether a change in the USAF promotion policy, which masked the education information to promotion boards, had an effect on promotion outcomes. He used cohort data from the USAF Officer Active Duty Master File from fiscal years 1992 through 2006. The data set used for analysis included 28,505 observations and 16 variables. For the estimation, Pearson used a logit regression model for both retention and promotion models because dependent variables for both models were binary. In addition, a difference-in-difference estimator was included in the

[38] Celik, *An Analysis of The Effect of Graduate Education on the Job Performance of Federal (DOD) Civilian Employees*, 64.

[39] Pearson, *The Effect of graduate Education on the Performance of Air Force Officers*, 4.

promotion logit model to determine whether the change of USAF promotion policy had an impact on the promotion outcomes. Explanatory variables consisted of demographics, professional, and education categories. Demographics categories included gender, race, age, marital status, and number of dependents. Professional categories consisted of commissioning source, current month in grade, prior enlisted experience, and Air Force Specialty Code (AFSC) career group. The education variable denoted the highest level of education such as a Baccalaureate or Master's degree and above.[40] For the two retention models (Captain and Major), the education variables were positive and statistically significant at the 1 percent and 10 percent significance level, respectively. For the promotion model, the education variable was positive and statistically significant at the 10 percent significance level. The partial effect of graduate education on the promotion to Major was 0.020 and statistically significant at the 10 percent significance level. The difference-in-difference estimator was negative and not significant. However, Pearson pointed out that the significance level was too low to make any conclusions about the change. From the results, he concluded that a graduate education had a significant positive effect on the retention of USAF Captains and Majors. Also, he concluded that a graduate education had a significant positive effect on promotion.[41] He found that Captains possessing an advanced degree had an increased likelihood of being promoted of 1.9 percentage points. In summary, Pearson's findings were consistent with human capital theory as well. Although the results were not conclusive, the attempt for a natural experiment using a difference-in-difference estimator was one of the strengths of his study. Like Celik's study, however, he did not consider the issue of possible attrition bias in his analysis.

Branigan conducted a study investigating the impact of a graduate education in general and more specifically, obtaining a degree from the Naval Postgraduate School

[40] Pearson, *The Effect of graduate Education on the Performance of Air Force Officers*, 42.

[41] Ibid., 92.

(NPS).[42] The retention of U.S. Marine Corps (USMC) officers and the joint probability of retention and promotion to the rank of Lieutenant Colonel were measured as outcomes. He analyzed data from 1998 through 2001 Lieutenant Colonel promotion boards. Also, he used accession cohort data or a "Longitudinal TBS file" from December 1979 through September 1984. The data set was provided by the DMDC to the Center for Naval Analyses (CNA). In addition, the Registrar at the NPS provided a data set about USMC officers who graduated from NPS between 1983 and 2003. The accession cohort sample included 6,507 observations and the promotion sample included 1,627 observations. He grouped variables into several categories such as outcomes, cognitive traits, affective traits, performance traits, demographic traits and career traits. From the preliminary analysis of the descriptive statistics, he found that USMC officers with graduate degrees from any source were more likely to survive the Lieutenant Colonel promotion board and more likely to be promoted than the officers without graduate degrees.[43] For the multivariate analysis, he used simple probit regressions for both the retention and promotion models. Additionally, he tried to use several models to correct for selection bias. To correct for sample selection bias, he used a bivariate probit model and a two-step Heckman model, which included unemployment rate as an instrumental variable. He argued that the unemployment rate significantly affects a stay-or-leave decision based upon Wielsma's study.[44] To correct self-selection bias or endogeneity, he again used a bivariate probit model and included a General Classification Test (GCT) score as an instrumental variable.[45]

Branigan found that the effects of a graduate education from any source, a graduate education from NPS, and a graduate education from sources other than NPS are

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[42] Branigan, *The Effect of Graduate Education on the Retention and Promotion of Marine Corps Officers*, 7.

[43] Ibid., 55.

[44] Wielsma, Ronald *"An Analysis of Factors Affecting Promotion, Retention and Performance for USMC Officer: A Graduate Education perspective"* Master's Thesis, Naval Postgraduate School, Monterey, California, March, 1996

[45] Branigan, *The Effect of Graduate Education on the Retention and Promotion of Marine Corps Officers*, 75.

all positively related to both retention and promotion to Lieutenant Colonel based upon the results of simple probit models. Table 2 indicates marginal effects of a graduate education from both models. The results of the Heckman model which dealt with sample selection indicated that an upward bias existed in the graduate education coefficient. He also concluded that unobserved factors, which predict both a graduate education and promotion to Lieutenant Colonel, are negatively related based upon results of the bivariate models for self-selection for a graduate education and the Heckman models. [46]

Table 2. Marginal Effects of Graduate Education on SURVIVE and SELECT

	ANY MASTERS	NPS	NOT_NPS
SURVIVE	.120	.106	.125
SELECT	.150	.107	.167

Source: From Branigan, The Effect of Graduate Education on the Retention and Promotion of Marine Corps Officers, table XXI, p. 84.

One of the strengths of Branigan's study is that he separately analyzed the effects of a graduate education by educational sources such as NPS and non-NPS. He raised and tried to correct biases regarding sample selection and self-selection. His finding regarding selection issues, however, were not conclusive. As he already mentioned in the limitation part of his study, more instrumental variables could be used for correction procedures. Also, none of the estimates produces simultaneously corrected estimates for sample selection and self-selection (endogeneity).

For the U.S. Navy officers, Buterbaugh conducted a study to analyze the effects of a graduate education and undergraduate academic performance on the promotion of officers to the USN Commander and Captain. [47] He used two data sets of officer promotion history files for fiscal year 1981 through 1984. Additionally, he separately conducted analysis for pre-drawdown (1981-1989) and drawdown periods (1990-1994). He also conducted analyses for five warfare communities of the USN separately and for

[46] Branigan, *The Effect of Graduate Education on the Retention and Promotion of Marine Corps Officers*, 83-84.

[47] Buterbaugh, *A Multivariate Analysis of the Effects of Academic Performance and Graduate Education on the Promotion of Senior U.S. Navy Officers,* 2.

the pooled sample. The five warfare communities were Surface Warfare Officers (SWO), Submarine Warfare Officers, Pilots, Naval Flight Officers (NFO's), and a community of combined Fleet Support and Supply Officers. Data sets were provided by code Pers-10 in the office of the Chief of Naval Personnel. The Commander data set had 12,372 observations and the Captain data set had 4,616 observations. He used OLS and logit regression for estimations. The dependent variable in his model was a binary variable named 'PROMOTED', which indicates whether the officer was promoted to the rank of Commander or Captain. Independent variables for his models were gender, race, graduate education, undergraduate grade point average (GPA), value of each undergraduate institution, whether the individual attended the U.S. Naval Academy (USNA), engineering field undergraduate degrees, prior enlisted status, and five occupational categories. Additionally, Chow tests were conducted to compare differences in determinants between the pre-drawdown period and drawdown period.

Based on estimates from the pooled sample, the effect of a graduate education on the promotion to Commander was positive and statistically significant.[48] From results of the five communities, he found that only the SWO community received significant positive effects from a graduate education and the undergraduate GPA and Support community received a significant effect from a graduate education. The effect of education on the promotion to Captain was not statistically significant. For a Captain promotion, only the Support community received a positive and significant effect from a graduate education. In general, the results of Buterbaugh's study are consistent with human capital theory. His study was unique because he tried to analyze the effect of a graduate education from not only a pooled sample but also for the different communities separately. He found that not all the communities received positive and significant effects from a graduate education on the promotion. In his study, he had restricted a graduate education as fully-funded and had not distinguished the type of graduate education. Considerations about biases regarding sample selection and endogeneity were not made.

[48] Buterbaugh, *A Multivariate Analysis of the Effects of Academic Performance and Graduate Education on the Promotion of Senior U.S. Navy Officers,* 43.

Another USN study was conducted by Bowman and Mehay. The purpose of their study was to examine the specific relationship between a graduate education and on-the-job performance for professional employees in a single and large hierarchical organization such as the USN.[49] The authors explained the military as an internal labor market that is characterized by a vertical hierarchy with a well-defined personnel system and they discussed that previous studies did not integrate the unique character such as structure, career paths, or the promotion process of certain firms or institutions.[50] They concentrated on the promotion to Lieutenant Commander because it is a significant control point in an officer's career and involves an up-or-out decision. The data set used for their analysis was the Navy's promotion history file, which provided background information on all officers reviewed for promotion from 1985 through 1990. They divided the data set and conducted separate analyses for Line officers and Staff officers. The Line officer data set included 4,230 observations and the Staff officer data set included 2,353 observations. The specifications of their model were built based upon human capital theory. For the cognitive abilities, they included a technical undergraduate degree, and a graduate degree. They also controlled for the accession source, such as the USNA, Reserve Officers' Training Corps (ROTC), Officer Candidate School (OCS), or the enlisted ranks as variables. In addition to these variables, the authors also included age, gender, race, marital status, and family status as demographic factors. Four fiscal year dummy variables were also included to account for different opportunities of promotion for each cohort.[51]

To analyze the unbiased effect of graduate education, they used simple probit regression models and assumed that graduate education variables were exogenous. Then, they added more controls to correct for the endogeneity bias, stemming from differences in motivation and career aspirations of USN officers getting a graduate degree. College GPA and early performance ratings were included as proxies for academic background

[49] Bowman and Mehay, Graduate education and employee performance, 453.

[50] Ibid., 455.

[51] Ibid., 456.

and early performance. As a second method, they used a bivariate probit model that used instrumental variables to correct for endogeneity of the graduate education variable. Sub-specialties, preference for graduate school, and a college performance variable (other than GPA) were included as instrument variables. Additionally, they investigated the effects of funded and non-funded education on the promotion separately.

Table 3 shows the effects of a graduate education from the results of the probit models and bivariate probit model estimation. From these results, the authors concluded that officers with any graduate degree were more likely to be promoted to Lieutenant Commander.[52] The probabilities of promotion were 10 to 15 points higher. However, they also concluded that a sizeable portion of the relationship between a graduate education and promotion is due to unobserved attributes that lead some officers to select (or be selected for) graduate education programs and to be more promotable based upon selection corrected results. They indicated that the effect of a graduate education was reduced by between 40 and 50 percent after correcting for selection.[53] In general, Bowman and Mehay's findings are consistent with human capital theory. An adequate sample size and sufficient theory-based specifications were used for their study. Their selection corrected models can be applicable for other services of the Armed Forces. However, some of the instrumental variables used for the selection correction model might have an impact on promotion.

[52] Bowman and Mehay, Graduate education and employee performance, 460.

[53] Ibid., 460.

Table 3. Coefficient of any Master's degree in Single Stage and Bivariate Probit Models

	1. No controls for ability/performance	2. controls for ability/performance	3.a. Bivariate probit	3.b. Error covariance (ρ)
Line Officers	0.376	0.265	0.198	0.124
	(0.073)[a]	(0.065)	(0.077)	(0.033)
	[0.093][b]	[0.065]	[0.056]	-
Staff Officers	0.503	0.376	0.188	0.170
	(0.063)	(0.073)	(0.108)	(0.039)
	[0.145]	[0.089]	[0.051]	-

Source: From Bowman & Mehay, Graduate education and employee performance, table 4, p. 460.
[a]Standard errors in parentheses.
[b]Marginal effects in brackets.

Finally, two studies conducted to investigate effect of graduate education for U.S. Army officers. Firstly, Kabalar conducted a multivariate study to examine the impact of a graduate education on promotion to U.S. Army Lieutenant Colonel.[54] In addition, the effects of basic demographic traits, prior enlisted status, and commissioning source on promotion were analyzed. The data set was the Active Duty Master File cohort data from fiscal years 1981 through 2001. For the study, only the first three cohort data were analyzed. Cohort 1981, 1982, and 1983 had 2,653, 2,274, and 1,907 observations, respectively. The pooled data set had a 44.8 percent promotion rate. He defined the binary dependent variable as promoted, which indicates outcomes of the Lieutenant Colonel promotion board. Independent variables were grouped into two categories. Demographic factors included gender, race, age, marital status, and number of dependents. Professional factors included education, commission source, DoD Primary Occupation Code (DPOG), and prior enlisted status. A logit regression model and classification tree model were used to investigate the relationship between a graduate education and promotion and to uncover data structure, respectively. Estimations were conducted for three different cohorts and a pooled sample. The odd ratios of the education variable for four estimations were positive and statistically significant. Table 4

[54] Kabalar, *Multivariate Analysis of the Effect of Graduate Education on Promotion to Army Lieutenant Colonel,* 4.

indicates the odd ratios of the education variable. The classification tree model confirmed the positive impact of a graduate education on promotion.[55]

Table 4. The Odd Ratios of the Education Variable

Year	95% Confidence Interval
1981	(1.87 – 2.70)
1982	(1.73 – 2.60)
1983	(1.29 – 1.99)
Pooled data	(1.79 – 2.25)

Source: From Kabalar, Multivariate Analysis of the Effect of Graduate Education on Promotion to Army Lieutenant Colonel, p. 35-36.

Findings about U.S. Army officers are also consistent with human capital theory. As discussed in his limitations part, he could distinguish the type and source of a graduate education. Also, a compared analysis among career fields by OPMS was not conducted. Furthermore, the selection and endogeneity issues were not considered in this study.

Secondly, Kahraman conducted another study using U.S. Army data to examine the relationship between an advanced education and the retention and promotion of Army officers.[56] He compared promotion rates among four education categories: college degree only, Master's degree, Doctorate degree, and professional degree. He focused on the promotion to Major. In addition, he investigated other retention behavior- or promotion-related factors. The data set used for his study was provided by the DMDC. The data set was called the Active Duty Master File and contained information about the U.S. Army officer cohorts from 1981 through 2001. Status of promotion, retention and some other elements such as education, marital status were tracked until 2004. From the more than 100,000 observations, he used 45,228 observations for the retention model and 12,092 observations for the promotion model. For the promotion analysis, he excluded officers who had not served more than 8 years. Promotion rate to Major for cohorts from 1981 through 1995 was 55.76%.

[55] Kabalar, *Multivariate Analysis of the Effect of Graduate Education on Promotion to Army Lieutenant Colonel*, 44.

[56] Kahraman, *The Effect of Advanced Education on the Retention and Promotion of Army Officers,* 3.

Kahraman, unlike the other previous studies, performed a survival analysis to capture not only the probability of promotion, but also the time of promotion. He implemented three methods of survival analysis. The three methods were survival pattern analysis, parametric regression models, and Cox (non-parametric) regression models. The dependent variable for the retention model was staying status of officer and for the promotion model the dependent variable was outcome of promotion to Major. Both dependent variables measure duration and he controlled for date censoring. His explanatory variables for both the retention and promotion models were the following: education level, gender, entry age, marital status, race-ethnicity, commission source, prior enlistment status, MOS, and commissioning year as an officer. His results showed that time to promotion to Major for an officer with a Master's or Doctorate degree or a professional degree was 0.2 percent less or 2.4 percent less, respectively, compared to an officer without an advanced degree. Having a Master's or Doctorate degree has a hazard of promotion that is 115.3 percent of that of an officer with a college degree. There was no significant effect found on the hazard of promotion for a professional degree. From these results, he concluded that having a graduate degree increased the probability of staying in the Army and also increased the probability of a promotion to Major.[57] Furthermore, an officer who has an advanced degree will stay longer than an officer who does not possess an advanced degree. In summary, Kahraman's findings are generally consistent with human capital theory and previous studies. Since he distinguished categories of an advanced degree and used survival methods for the analysis, his study was unique among other previous studies. As he mentioned in his limitation section, however, he could not distinguish types and sources of advanced degree because of data limitations.

[57] Kahraman, *The Effect of Advanced Education on the Retention and Promotion of Army Officers,* 151.

F. CHAPTER SUMMARY

In this chapter, several key concepts of the human capital theory are discussed such as the investment in human capital as well as general and specific training. The U.S. Army has unique characteristics as an internal labor market and also encourages officers to earn graduate degrees to increase their productivity. An officer can be selected for either fully- or partially-funded programs to obtain a graduate degree which is normally related with one's MOS or FA as designated by the OPMS. Company and field grade officers in the Army are managed by the OPMS which has four career fields. In 2005, the OPMS was reorganized as a new OPMD design which now has three career fields. In this study, career fields are in accordance with the former OPMS design.

In addition, several previous studies were reviewed in regards to the effect of a graduate education on the promotion of officers from four services of the U.S. Armed Forces as well as a DoD civilian. In general, findings of all the discussed studies were consistent with human capital theory, which particularly explained the concept that investment in human capital, namely in this study graduate education, increases the productivity of employees.

Gibbs, Celik, Pearson, and Kabalar had not dealt with any potential biases in their data sets. Thus, their estimators were likely biased. On the contrary, Blackburn and Neumark, Branigan, and Bowman and Mehay used selection correction methods for the young workers in private sectors, USMC, and USN to obtain the pure effect of a graduate education. Since Bowman and Mehay used a promotion history file, they only dealt with bias regarding self-selection or endogeneity of a graduate education variable. Branigan dealt with both sample selection and self-selection biases. However, his findings were inconclusive and he did not attempt to correct for both biases simultaneously. Since the data set for this study possesses problem of both biases, a double selection model will be discussed and implemented to correct both biases, simultaneously. Buterbaugh conducted his analysis for five warfare communities as well as for a pooled sample of USN officers. Kabalar and Kahraman did not attempt to implement the concepts of career field-based

OPMS. In this study, the analyses for four career fields of the U.S. Army will be conducted to compare the effects of a graduate education on the promotion of Army field grade officers.

III. DATA AND METHODOLOGY

A. DATA SUMMARY AND DESCRIPTIVE STATISTICS

The data set used for this study was the U.S. Army Officer Active Duty Master file. It was provided by the DMDC in Monterey, California. The initial data set contained information about cohorts from 1981 through 2001. Variables such as education, pay grade (rank), and marital status were tracked until 2004. Since the analysis considers the promotion to Lieutenant Colonel and Colonel, only cohorts entering from 1981 through 1985, and 1981 through 1982 were used. This is because each promotion requires at least fifteen and twenty one years of service, respectively. Observations with miscoded or clearly erroneous information were excluded for the analysis. In addition officers who belong to special branches such as medical and judicial, which require officers to possess a graduate or professional degree at the time of commission, are excluded from the samples because their ability is systematically different that of most of other officers and they were already screened by a graduate education. The final Lieutenant Colonel sample has a total of 25,839 observations and the Colonel sample has a total of 1,785 observations. Since the complete results of the promotion to Lieutenant Colonel can be available only for an officer who stayed at least seventeen years in the U.S. Army and was promoted to Major, the sample of the Lieutenant Colonel data set used for the simple probit regression model includes 6,168 observations. For the same reason, the sample of the Colonel data includes 1,134 observations. The rest of the observations, who did not stay enough time of service to be reviewed for promotions, are used for the correction model for sample selection bias. Levels of cognitive ability and experience for initial stage of most officers are very homogeneous because they all should possess a Bachelor's Degree and almost everyone is commissioned as a Second Lieutenant.

B. VARIABLES AND DESCRIPTIVE STATISTICS

The choice of control variables for this study was based on the implications of human capital theory and previous studies by Kabalar,[58] Kahraman,[59] and Bowman and Mehay[60] regarding investment in human capital. The names and descriptions of variables are shown in Table 5. The dependent variable of analysis is outcomes of promotion selection, called 'Promoted', for both data sets. Independent variables are separated into the following four categories: cognitive factors, accession source, demographic factors, and fiscal year dummy variables. The initial data set does not contain any ability proxies such as performance in college, types of Bachelor's Degree, or any test scores except for status of education certificate and years of schooling.

Table 5. Names and Descriptions of Variables

Variable name	Variable description
Dependent variables	
Promoted to O5	=1, if officer promoted to Lieutenant Colonel (O5)
Promoted to O6	=1, if officer promoted to Colonel (O6)
Independent variables	
(1) Cognitive factor	
Graduate education	=1, if officer possess a graduate degree
(2) Affective factors	
USMA	=1, if source of commission is US Military Academy
ROTC	=1, if source of commission is Reserve Officers' Training Corps
OCS	=1, if source of commission is Officer Candidate School
Other sources of commission	=1, if source of commission is other than USMA, ROTC, or OCS
Prior Enlistment	=1, if officer is prior enlisted / =0, otherwise
Operations	=1, if career field is Operations
Institutional Support	=1, if career field is Institutional Support
Information Operations	=1, if career field is Information Operations
Operational Support	=1, if career field is Operational Support
Other career field	=1, if career field is other than Operations, Institutional

[58] Kabalar, *Multivariate Analysis of the Effect of Graduate Education on Promotion to Army Lieutenant Colonel*.

[59] Kahraman, *The Effect of Advanced Education on the Retention and Promotion of Army Officers.*

[60] Bowman and Mehay, Graduate education and employee performance.

	Support, Information Operations, or Operational Support
(3) Demographic factors	
Female	=1, if gender is female / =0, Male
White	=1, if race is white
Black	=1, if race is black
Other race	=1, if race is other than white or black
Married	=1, if officer is married / =0, otherwise
Married with children	=1, if officer is married with children
Divorced with children	=1, if officer is divorced with children
Entry age	Continuous, Age at entry
Number of dependents	Continuous, Number of dependents at the time of entry
(4) Fiscal Year dummies	
Fiscal year	Dummy variables for fiscal year of commission

In this analysis the graduate education variable is the variable of interest. The study does not distinguish between various forms of graduate education. Therefore, the graduate education indicator includes not only Master's degrees but also professional and Doctorate degrees. Since there is no information about the source of the graduate education, namely fully- or partially-funded or self-payment, it is not distinguished.

To capture institutional factors I also include the source of commission, status of prior enlistment, and career fields according to the OPMS. Source of commission includes the U.S. Military Academy (USMA), ROTC, OCS, and other sources of commission. The career field variables are included to control for differences of promotional opportunity among career fields. The career field variables are Operations, Institutional Support, Information Operations, Operational Support, and branches other than career fields. These variables are coded according to the DoD instruction 1312.1-1.[61] The demographic factors include gender, race, marital and family status, and entry age. Additionally, four fiscal year dummy variables are included to control for differences of promotional opportunity among cohorts.

[61] Department of Defense Office of the Undersecretary of Defense Personnel and Readiness, *"Occupational conversion index: enlisted / officer / civilian,"* 350-355.

Table 6. Descriptive Statistics of the Lieutenant Colonel Sample by Education Status

Variable	Officers with a graduate degree (n=3,932)		Officers without a graduate degree (n=2,236)		Standardized difference
	Mean	Std. Dev.	Mean	Std. Dev.	
Promotion rate	.845	.362	.682	.466	0.399
Female	.126	.331	.10	.304	0.071
White	.892	.310	.855	.353	0.116
Black	.085	.279	.124	.330	0.130
Other race	.023	.149	.021	.145	0.008
USMA	.268	.443	.136	.343	0.317
ROTC	.290	.454	.328	.470	0.082
OCS	.005	.073	.009	.094	0.044
Other sources of commission	.436	.496	.526	.499	0.180
Married	.796	.403	.769	.421	0.066
Married with children	.067	.250	.088	.283	0.078
Divorced with children	.171	.377	.188	.391	0.044
Prior enlisted	.143	.350	.164	.370	0.060
Entry age	22.847	2.241	23.042	2.155	0.088
Number of dependents	.989	.649	.988	.695	0.000

The descriptive statistics of the two samples are shown in Tables 6 and 7. Alongside sample means and standard deviations, I also present standardized differences that are obtained by dividing the sample mean difference by the sample standard deviation. The standardized difference is meant to highlight large differences in variable means between treatment and control groups. Differences exceeding a quarter of a standard deviation will be considered large both statistically, and practically. About 78.6 percent of the officers in Lieutenant Colonel sample were promoted to Lieutenant Colonel. The descriptive statistics of the Lieutenant Colonel sample indicate that about 63.7 percent of the officers who were commissioned from 1981 through 1985 possessed a graduate degree before other officers were promoted to Lieutenant Colonel. The promotion rate to Lieutenant Colonel of officers with a graduate degree is 84.5 percent. It is 16.3 percentage points higher than the 68.2 percent of officers without a graduate

degree. This difference exceeds a quarter of a standard deviation, and thus appears quite significant. The portion of officers who possessed a graduate degree and were commissioned by the USMA was about 13.2 percentage points higher than officers commissioned by the USMA without a graduate degree. Also, its standardized difference is bigger than 0.25 range. The portion of officers who possessed a graduate degree and were commissioned but not by the USMA, ROTC, and OCS was about 9 percentage points lower than officers without a graduate degree and commissioned but not by the USMA, ROTC, and OCS. The mean entry age of officers with a graduate degree was .195 year lower than that of officers without a graduate degree. Overall, officers who were promoted to Lieutenant Colonel appear to be better educated and more likely to have obtained graduate education. In addition, officers who obtain graduate degrees appear to be USMA graduates and slightly younger than officers without a graduate degree in Lieutenant Colonel sample.

Table 7. Descriptive Statistics of the Colonel Sample by Education Status

Variable	Officers with a graduate degree (n=954)		Officers without a graduate degree (n=180)		Standardized difference
	Mean	Std. Dev.	Mean	Std. Dev.	
Promotion rate	0.518	0.500	0.406	0.492	0.224
Female	0.094	0.292	0.061	0.240	0.117
White	0.911	0.285	0.883	0.322	0.095
Black	0.062	0.241	0.089	0.285	0.109
Other race	0.027	0.163	0.028	0.165	0.003
USMA	0.356	0.479	0.106	0.308	0.539
ROTC	0.311	0.463	0.472	0.501	0.340
OCS	0.002	0.046	0.000	0.000	0.050
Other sources of commission	0.330	0.471	0.422	0.495	0.194
Married	0.808	0.394	0.744	0.437	0.159
Married with children	0.059	0.235	0.128	0.335	0.271
Divorced with children	0.192	0.394	0.256	0.437	0.159
Prior enlisted	0.157	0.364	0.189	0.393	0.086
Entry age	22.448	1.691	22.894	1.854	0.259
Number of dependent	1.108	0.460	1.206	0.604	0.200

About 50 percent of the officers in Colonel sample were promoted to Colonel. The descriptive statistics of the Colonel sample indicates that about 84.1 percent of officers who were commissioned between 1981 and 1982 possessed a graduate degree before the promotion to Colonel. The promotion rate of officers with a graduate degree was 51.8 percent and the promotion rate of officers without a graduate degree was 40.6 percent. The percentage of the USMA graduates with a graduate degree was about 25 percentage points higher than that of the USMA graduates without a graduate degree. This difference is more than half a standard deviation, and therefore quite large. The percentage of the ROTC with a graduate degree was about 16.1 percentage point lower than that of the ROTC without a graduate degree. This difference is more than a quarter of a standard deviation, suggesting that ROTC officers are significantly less likely to have a graduate degree. The portion of officers who possessed a graduate degree and are married with children was about 6.9 percentage points lower than officers without a graduate degree and married with children. The standardized difference is larger than a quarter of a standard deviation, suggesting that married officers with children are significantly less likely to obtain graduate degrees. The mean entry age of officers with a graduate degree was 0.446 year lower than that of officers without a graduate degree. Its standardized difference is bigger than 0.25 as well. Overall, officers who earn graduate degrees are more likely to be USMA graduates and younger than officers without a graduate degree in Colonel sample.

C. METHODOLOGY AND MODELS

1. Promotion Model for Both Samples

Since the dependent variable of the two data sets is a binary variable, a probit regression was used for the analyses. Initially I assume that there are no sample selection issues and endogeneity of the graduate education variable. The four independent variable categories according to human capital theory and previous studies were included in the specifications. The model for both samples is the following, and represents a reduced-form promotion probability:

$$P(y=1 \mid s=1, X, F, D) = \Phi(\beta_0 + \beta_{1k} X_{ki} + \beta_2 F_i + \beta_3 D_i + u_i) \quad (1)$$

where variable D is the graduate education variable, F is a vector of career field variables, and X is a vector of other factors such as affective factors yet not career field variables, demographic factors, and fiscal year dummies that are expected to affect the outcome of promotion selection. Variable s is a dependent variable which takes the value of 1 if an individual officer stayed enough to be promoted to Lieutenant Colonel or Colonel, and was already promoted to Major or Lieutenant Colonel. Variable y is a dependent variable which takes the value of 1 if an individual officer was promoted to Lieutenant Colonel in the Lieutenant Colonel sample. It also takes the value of 1 if the individual officer was promoted to Colonel in the Colonel sample.

2. Promotion Model for Each Career Fields

Simple probit regressions were used to investigate the effects of a graduate education by each career field under the assumption that there is no sample selection or endogeneity issue. The model built for the career field estimations is as follows:

$$P(y=1 \mid s=1, X, D) = \Phi(\beta_0 + \beta_{1k} X_{ki} + \beta_2 D_i + u_i) \quad (2)$$

where variable D is an indicator for graduate education, X is a vector of variables that are expected to affect promotions, including demographics, fiscal year dummies, as well as affective factors, not including career field variables. Since career management of the Army field grade officers are governed by career fields of OPMS, it is suspected that probabilities of promotions may vary by career fields. Therefore, the career field dummies are excluded because estimations will be separately conducted for each career field.

3. Correction of Sample Selection Bias

Both models may produce biased estimates since they are estimated on a truncated sample. Both explanatory variables and promotion outcomes can always be observed for those who stay in the military. This information, however, can not be

observed for officers who did not stay at least seventeen years to be promoted to Lieutenant Colonel, or twenty three years for the promotion to Colonel in the U.S. Army. If those who leave the military are systematically different from those who stay, then the sample used in estimations will produce results that are not representative of the entire population, and my result in biased estimators of the parameters.

To correct for the sample selection bias, I adopt the Heckit method, developed by Heckman[62], for both promotion outcomes. In this study, the equation of primary interest is the promotion equation (1) below. Now suppose that we can characterize the stay decision with equation (3):

$$P(y=1 \mid s=1, X, F, D) = \Phi(\beta_0 + \beta_{1k} X_{ki} + \beta_2 F_i + \beta_3 D_i + u_i) \quad (1)$$

$$P(s=1 \mid Z, X, F, D) = \Phi(\gamma_0 + \gamma_1 Z_i + \gamma_2 X_{ki} + \gamma_3 F_i + \gamma_3 D_i + v_i) \quad (3)$$

where s is an indicator for the decision to stay and takes the value of 1 if an individual officer chooses to stay in service for seventeen years or more, until the point of promotion to Lieutenant Colonel, or twenty three years or more for the promotion to Colonel. The variable Z in (3) represents instrumental variables that explain the stay-leave decision but do not affect promotion, and v is the error term of the selection equation.

Traditionally, the Heckit method would involve a two-step estimation. Equation (3) is estimated first for the entire data set (stayers and leavers) via probit. This estimation also yields an estimate for the inverse Mills' ratio, $\hat{\lambda}_i$. The inverse Mills' ratio is calculated using the formula:

$$\hat{\lambda}_i = \frac{\phi(\hat{\gamma}_0 + \hat{\gamma}_1 Z_i + \hat{\gamma}_2 X_{ki} + \hat{\gamma}_3 F_i + \hat{\gamma}_3 D_i)}{\Phi(\hat{\gamma}_0 + \hat{\gamma}_1 Z_i + \hat{\gamma}_2 X_{ki} + \hat{\gamma}_3 F_i + \hat{\gamma}_3 D_i)}$$

[62] James J. Heckman discussed the correction method of sample selection in his article; "The Common Structure of Statistical Models of Truncation, Sample Selection, and Limited Dependent Variables and a Simple Estimator for Such Models," *Annals of Economic and Social Measurement* 5 (1976): 475-492.

This term can be thought of capturing all the information from the full sample that would lead to bias if equation (1) were estimated via OLS. Adding the inverse Mills ratio $\hat{\lambda}_i$ for the selected sample as an additional regressor to equation (1) will yield an unbiased estimate of the graduate education variable. However, a joint estimation of both equations via Maximum Likelihood (MLE) is more efficient (has a smaller variance). Since in this case both outcomes are binary, I perform an MLE estimation that takes into account the fact that both equations have limited dependent variables. (see Wooldridge, 2002, for a detailed discussion).

All the independent variables, which are part of the vector X of the promotion equation, should be included in the selection equation. Furthermore, instrumental variables should be included in the selection equation as this is critical for the selection correction. A valid instrumental variable (IV) should not belong in the promotion outcome, but should explain selection into the sample (i.e. the stay-leave decision). For this analysis, I use "the national unemployment rate," "whether the person is married to a military spouse", and "member of the Special Forces" as instrumental variables. An explanation of the rationale behind these exclusion restrictions follows.

The "unemployment rate" is already introduced and used as an instrumental variable to correct sample selection bias of the promotion equation by Branigan's study. Unemployment rate can be an appropriate instrumental variable because it has no apparent relationship with promotion, but it may affect the decision of an individual officer's stay-or-leave decision. Unemployment rate takes the value of the national unemployment rate for the fiscal year when officers finished their active duty service obligations (ADSOs). This variable would serve as a proxy for civilian employment opportunities, which may affect the stay-leave decision. According to Army Regulation 350-100, ADSOs for the USMA, ROTC scholarship, nonscholarship ROTC, and OCS are five, four, three, and three years, respectively.[63]

[63] Headquarters Department of the Army, *Officer Active Duty Service Obligations*, 2.

"Being married to a military spouse" is not a criterion or a significant factor of the promotion selection. However, it is likely that an officer may not leave the U.S. Army if he or she has a spouse who serves in the Armed Forces. Thus, the indicator for being married to a military spouse may serve as an instrumental variable in the selection equation.

Bowman and Mehay used occupational specialties as instrumental variables arguing that the cost of attending graduate school varies across occupational specialties, and that, after controlling for field, occupation specialty does not affect promotion.[64] In the same vein I use an indicator for "Member of Special Forces" as an instrumental variable for the stay-leave decision. Special Forces officers are usually in charge of dangerous tasks compared to other occupations of the Army. In addition, officers in this occupation are more frequently separated from their families due to more intense and specific training and special missions. Furthermore, private security firms outside of military offer better compensation for special force officers. Therefore, it is suspected that Special Forces officers are more likely leave the Army. However, being in the Special Forces does not affect the probability of promotion because the Special Forces branch is one of occupations within Operations career field. Therefore, opportunities of promotion should be the same within the operations field, regardless of occupation. And all officers can be assigned to Special Forces at commission because it does not require possessing higher cognitive ability or certain specific training. Therefore, the variable "member of Special Forces" can be included as an instrumental variable into the selection equation.

To determine the existence of sample selection bias and check the validity of instrumental variables, the correlation of the residuals in the two equations (ρ), will be estimated and a likelihood ratio test on whether ρ is statistically significant will be conducted.

64 Bowman and Mehay, Graduate education and employee performance, 458.

4. Correction for Endogeneity

Several previous researchers such as Bowman and Mehay and Branigan discussed that the graduate education variable can not be assumed as an exogenous variable, but it is an endogenous variable because the decision to obtain graduate education depends on individual preferences, the cognitive ability to be selected for a fully- or partially-funded program, the different possibility of getting a chance to attend career field programs, and the opportunity cost of attending a program.

In this study, an instrumental variable regression method is used to correct the possible bias of the graduate education variable, which is likely caused by endogeneity. It is a two-stage least squares (2SLS) method using instrumental variables.[65] The two-stage least squares model is specified below:

$$P(y=1 \mid s=1, X, F, D) = \beta_0 + \beta_{1k} X_{ki} + \beta_2 F_i + \beta_3 D_i + u_i \quad (4)$$

$$D_i = \pi_0 + \pi_1 IVs_i + \pi_2 X_{ki} + \pi_3 F_i + e_i \quad (5)$$

where variable D is the graduate education variable, and variable IVs is the set of three instrumental variables. The vector X is other exogenous independent variables while e is an error term of Equation (5). The instrumental variables should not be correlated with the promotion outcome, but should be correlated with the graduate education variable. Four instrumental variables used for Equation (5) are "stationed outside of U.S.," "permanent home is outside of the U.S.," and "member of the Special Forces."

The first instrumental variable named "stationed outside of U.S." takes a value of one if an officer was stationed outside of the U.S. at least once in his or her career. An officer who was stationed outside of the U.S. has less of a chance to attend and finish any type of graduate education program than an officer who only served in the U.S. The second instrumental variable named "permanent home is outside of the U.S." takes a value of one if an officer's permanent home is outside of the U.S. at the time of

[65] The estimations are carried out using Stata's *ivreg2* routine.

commission, which means that the officer's native language is not likely English. It is suspected that an officer who does not speak or write English fluently will be less likely to obtain a graduate education because of the extra burden that education in a non-native language will present both during the application process and during graduate studies. His or her opportunity cost of attending a graduate program is larger than officers whose native language is English. The third instrumental variable named "member of Special Forces" takes a value of one if an officer's branch is Special Forces. The officers in the Special Forces branch are more likely deployed for several combat tours outside of the U.S. They have lots of special training both in the U.S. and overseas. Many Special Forces officers tend to stay in the unit and acquire experience for their career management just like officers in the combat branches. Therefore, it is suspected that Special Forces officers are not likely to obtain a graduate education to enhance their productivity.

5. Correction for Both Sample Selection Bias and Endogeneity

None of previous studies, which are discussed in the Chapter II, had implemented a double-selection model, which corrects both sample selection bias and endogeneity simultaneously. Wooldridge proposes a method[66] for correcting the sample selection problem when one variable is endogenous. The double selection model is specified as follows:

$$P(y=1 \mid s=1, X, F, D) = \beta_0 + \beta_{1k} X_{ki} + \beta_2 F_i + \beta_3 D_i + u_i \tag{4}$$

$$D_i = \pi_0 + \pi_1 Z_{2i} + \pi_2 X_{ki} + \pi_3 F_i + e_i \tag{5}$$

$$P(s=1 \mid Z_1, X, F, D) = \Phi(\gamma_0 + \gamma_1 Z_{1i} + \gamma_2 X_{ki} + \gamma_3 F_i + \gamma_3 D_i + v_i) \tag{3}$$

[66] Wooldridge introduced and explained about method to correct the sample selection bias and endogeneity using the inverse Mills ratio in his book, *Econometric Analysis of Cross Section and Panel Data* (567-568).

where Z_2 denotes a set of exogenous instrumental variables used for the graduate education variable and the vector Z_1 is a set of instrumental variables which are used for selection equation. The procedure for the corrections is as follows:

(a) Estimate Equation (3) using all observations. Obtain the estimated inverse Mills ratios $\hat{\lambda}_i$.

(b) Using the selected subsample (for which both outcomes of promotion selection and status of a graduate education are observed), estimate Equations (4) and (5), including the estimated inverse Mills ratios $\hat{\lambda}_i$ from Equation (5) as an additional instrumental variable and estimate the system by 2SLS.[67]

The instrumental variables used for Equation (3) are "unemployment rate", "military spouse", and "member of Special Forces". Also, the three instrumental variables used for the 2SLS instrumental variable regression are "stationed outside of U.S.", "permanent home is at the outside of U.S.", and "member of Special Forces". A test for the null hypothesis of no selection issues can be found using the usual 2SLS t-statistic for the coefficient of the inverse Mills ratios $\hat{\lambda}_i$.

D. CHAPTER SUMMARY

In this chapter, a summary of the initial data set as well as the dependent and independent variables were introduced with descriptive statistics. Furthermore, five models were built and introduced for the estimations. The five models include the promotion model for both the Lieutenant Colonel and Colonel samples, the promotion model for each career field, the model for sample selection bias, the model for endogeneity, and the model for both sample selection bias and endogeneity. The Heckit method was used for the correction of sample selection bias and the instrumental variable

[67] This procedure is an application of Wooldridge's Procedure 17.2 from his book, Econometric Analysis of Cross Section and Panel Data (568).

regression method was used for correction of endogeneity. Finally, the double selection model was used for the correction of both sample selection bias and endogeneity.

IV. RESULTS OF ESTIMATION

A. PROMOTION TO LIEUTENANT COLONEL

1. Pooled Sample

As the first part of a multivariate analysis, a MLE estimation of a probit regression model for the Lieutenant Colonel sample was conducted and the results are displayed in Table 8. The sample used for estimation included the officers who were promoted to Major and served at least seventeen years to be reviewed for promotion to Lieutenant Colonel. The log likelihood value is -2970.275 and the pseudo R-squared is 0.0725 for this estimation.

Table 8. Estimation Results of the Lieutenant Colonel Sample

Dependent variable: Promoted to Lieutenant Colonel		
	Independent variables	
	(1) Coefficient	**(2) Partial Effects**
Graduate education	0.507	0.148
	(0.039)***	(0.012)***
Operations	-0.248	-0.066
	(0.060)***	(0.015)***
Institutional Support	-0.043	-0.012
	(0.107)	(0.031)
Information Operations	0.022	0.006
	(0.124)	(0.034)
Operational Support	-0.062	-0.018
	(0.093)	(0.027)
Female	0.037	0.010
	(0.061)	(0.017)
White	0.331	0.101
	(0.118)***	(0.039)***
Black	0.221	0.057
	(0.130)*	(0.031)*
USMA	0.110	0.030
	(0.055)**	(0.014)**
ROTC	0.178	0.048
	(0.046)***	(0.012)***

OCS	0.339	0.080
	(0.262)	(0.052)
Married	0.161	0.047
	(0.109)	(0.033)
Married with children	0.011	0.003
	(0.107)	(0.030)
Divorced with children	0.021	0.006
	(0.119)	(0.033)
Prior Enlistment	-0.049	-0.014
	(0.055)	(0.016)
Entry Age	-0.046	-0.013
	(0.009)***	(0.003)***
Number of Dependents	0.032	0.009
	(0.048)	(0.013)
Cohort82	0.206	0.054
	(0.057)***	(0.014)***
Cohort83	0.287	0.072
	(0.064)***	(0.014)***
Cohort84	0.466	0.116
	(0.054)***	(0.012)***
Cohort85	0.603	0.144
	(0.066)***	(0.013)***
Constant	0.879	
	(0.281)***	
Observations	6168	
Log likelihood	-2970.275	
Pseudo R-squared	.0725	

Standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

The graduate education variable, the variable of interest, is positive and statistically significant at the 1 percent level. The partial effect of the graduate education variable is calculated for an officer with average characteristics. According to estimates in column (2), a graduate degree increases the probability of promotion to Lieutenant Colonel by 0.148 and is statistically significant.

Only one career field variable, namely Operations, is statistically significant and has a negative effect. The source of commission variables USMA and ROTC are statistically significant and have a positive effect. Among the demographic factors, only the entry age is statistically significant and has a negative effect on promotion. All four fiscal year dummy variables are statistically significant and have a positive effect.

2. Career Fields by OPMS Design

As a next step, estimations for four career fields were conducted and partial effects of the graduate education variables are displayed in Table 9. Complete results for all four career field estimations are displayed in Appendix A. For these estimations, officers who were promoted to Major and stayed until seventeen years of service are included in the sample.

Table 9. Effects of a Graduate Education on the Promotion to Lieutenant Colonel by Career Field (Partial Effects)

	Operations	**Institutional Support**	**Information Operations**	**Operational Support**	**Others**
Graduate education	0.144 (0.014)***	0.070 (0.054)	0.117 (0.057)**	0.156 (0.063)**	0.216 (0.035)***
Observations	4308	308	205	458	881

Standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

The partial effects of the graduate education variables are generally significant and positive except for the Institutional Support career field, which is not significant. The category "Others", which consists of some branches that are not included in any of the four major career fields, received the highest effect of a graduate education on the promotion to Lieutenant Colonel. The effect of graduate education is lowest for the Informational Operations career field, but it remains statistically significant. Partial effects of Operations and Operational Support career fields are 0.144 and 0.156, respectively, and these partial effects are similar to that of the pooled sample, 0.148.

B. PROMOTION TO COLONEL

1. Pooled Sample

The same MLE probit estimation was conducted for the Colonel sample. The sample includes the officers who were promoted to Lieutenant Colonel and served at least twenty-three years in the U.S. Army to be reviewed for the promotion to Colonel.

The results of the estimation including coefficients and partial effects are displayed in Table 10. The log likelihood value is -734.242 and pseudo R-squared is 0.0642.

Table 10. Estimation Results of the Colonel Sample

Dependent variable: Promoted to Colonel		
	Independent variables	
	(1) Coefficient	**(2) Partial Effects**
Graduate education	0.334	0.132
	(0.109)***	(0.042)***
Operations	0.040	0.016
	(0.115)	(0.046)
Institutional Support	-0.287	-0.113
	(0.187)	(0.072)
Information Operations	-0.246	-0.097
	(0.224)	(0.087)
Operational Support	-0.256	-0.101
	(0.169)	(0.066)
Female	0.230	0.091
	(0.143)	(0.056)
White	0.169	0.067
	(0.249)	(0.098)
Black	0.342	0.134
	(0.290)	(0.110)
USMA	0.134	0.053
	(0.105)	(0.042)
ROTC	-0.004	-0.002
	(0.097)	(0.039)
Married with children	0.748	0.278
	(0.279)***	(0.089)***
Divorced with children	-0.222	-0.088
	(0.102)**	(0.040)**
Prior Enlistment	-0.051	-0.020
	(0.116)	(0.046)
Entry Age	-0.005	-0.002
	(0.026)	(0.010)
Number of Dependents	-0.364	-0.145
	(0.160)**	(0.064)**
Cohort82	-0.646	-0.253
	(0.080)***	(0.030)***
Constant	0.312	
	(0.691)	

Observations	1132	1132
Log likelihood	-734.242	
Pseudo R-squared	.0642	

Standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

The coefficient of the graduate education variable is positive and statistically significant at the 1 percent level. The partial effect of the graduate education variable is 0.132 and is about 0.016 percentage points lower that that of the Lieutenant Colonel sample. It can be interpreted that a probability of promotion to Colonel of an average officer with a graduate degree in the sample is 13.2 percentage points higher than an average officer without a graduate degree in the sample.

The coefficients of many independent variables are not statistically significant. The partial effect of the "Married with children" variable is 0.278 and that of the "Divorced with children" variable is -0.088. The partial effect of the "Number of dependents" variable is -0.145. It can be interpreted that one more dependent than the average decreases an officer's probability of promotion by 0.145. The fiscal year dummy variable, cohort 82, is negative and statistically significant.

2. Career Fields by OPMS Design

The MLE probit estimations for the four career fields using the Colonel sample were conducted and the partial effects around the mean of the graduate education variable are displayed in Table 11. Complete results of the four career field estimations using the Colonel sample can be found in Appendix A.

Table 11. Effects of the Graduate Education on the Promotion to Colonel by Career Field (Partial Effects)

	Operations	**Institutional Support**	**Information Operations**	**Operational Support**	**Others**
Graduate education	0.130 (0.048)***	-0.209 (0.292)	0.026 (0.289)	0.050 (0.233)	0.290 (0.119)**
Observations	765	71	42	96	156

Standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

The partial effects of the graduate education variables for career fields such as Institutional Support, Information Operations, and Operational Support are not statistically significant due to small sample sizes. The partial effect for the Operation career field is 0.130 and is similar to that of the pooled sample, 0.132. The branches and functional areas other than the four career fields received the highest and significant effect of graduate education. It can be interpreted that the probability of promotion for an average officer with a graduate education is 0.29 higher than an officer without a graduate degree in the "Others" category.

C. CORRECTION FOR SELECTION BIAS AND ENDOGENEITY FOR POOLED SAMPLED OF THE LIEUTENANT COLONEL SAMPLE

The previous estimations using MLE probit regression were conducted based upon assumptions that the data sets do not have a selection problem and the graduate education variable is exogenous. Several previous studies, however, indicate that the education variable is endogenous and the data set used for this study will likely possess the problem of sample selection. Therefore, three models were estimated to correct sample selection bias and endogeneity both separately and simultaneously. The coefficients and partial effects of the graduate education variables from the estimation results are displayed in Table 12. The complete results of the three estimations are displayed in Appendix B.

Table 12. Coefficients and Partial Effects of the Graduate Education Variables from the Results of Correction Estimations

	Probit Model	**Correction of sample selection**		**Correction of endogeneity**	**Double Selection Model**
		Two-step	**MLE**		
Graduate education	0.507 [0.148] (0.039)***	0.056 (0.029) **	0.250 [0.060] (0.104)**	.253 (0.090)***	.239 (0.078)***
Partial effect change	-	↓ 0.092	↓ 0.088	↑ 0.105	↑ 0.091
Percent change	-	↓ 62.2%	↓ 59.5%	↑ 70.9%	↑ 61.5%

Standard errors in parentheses, Partial effects in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%

1. Results of Sample Selection Correction Model

The correction model of sample selection was estimated using the Heckit method with three instrumental variables such as "unemployment rate," "military spouse," and "member of Special Forces." The whole observations of the Lieutenant Colonel sample are used for the first stage regression and a selected sample is used for second stage regression to correct sample selection bias. This estimation is conducted based upon assumptions that the selected sample possesses the problem of sample selection and the graduate education variable is exogenous.

From the result of the two-step Heckit method, the partial effect of the graduate education variable is 0.056 and is significant at the 5 percent level. This partial effect is decreased by 9.2 percentage points of the probability of promotion from that of simple probit estimation and its effect is reduced by about 62.2 percent. It indicates that the selected sample has problems in regards to upward bias of the graduate education variable. Result of MLE estimation indicates that the chi-square statistics and the p-value of the LR-test of independent equations are 6.68 and 0.0098, respectively. The output of the LR-test indicates that there is sample selection problem in the selected sample data set. In the first stage regression, the instrumental variable "military spouse" is positive and statistically significant and "member of Special Forces" is negative and statistically significant. The "unemployment rate" variable, however, is not significant with its p-value of 0.622. The partial effect of the graduate education variable is 0.060 and is significant at the 5 percent level. This partial effect is decreased by 8.8 percentage points of the probability of promotion from that of simple probit estimation and its effect is reduced by about 59.5 percent. It indicates that the selected sample has problems in regards to upward bias of the graduate education variable as well.

2. Results of Endogeneity Correction Model

The correction model for endogeneity was estimated using the instrumental variable regression method with four instrumental variables such as "stationed outside of the U.S,." "permanent home is outside of the U.S.," and "member of Special Forces."

This estimation was conducted based upon assumptions that there was no sample selection bias and the graduate education variable was endogenous.

The F-statistics and p-value for the first stage regression are 30.30 and 0.000, respectively. It indicates that the three instrumental variables are significantly correlated with the endogenous variable, namely graduate education. The "stationed outside of the U.S." and "permanent home is outside of the U.S." variables are negative as expected as is the assumption for instrumental variables and statistically significant at 1 percent and 10 percent in the first stage regression, respectively. The "member of Special Forces" variable is positive and significant at 1 percent. The sign of "member of Special Forces" variable has the opposite sign that expected. It could be that the officers in the Special Forces branch may be given more opportunities to attend a graduate school as a type of incentive for hardship of training or combat tours. Also, it could be that the officers more likely attend a graduate program to avoid family separation because of deployment.

The partial R-squared from the first stage regression, representing the correlation between the education variable and the instrumental variables is 0.0122. This result indicates that the instrumental variables are strongly correlated with valuable measures. The null hypothesis of the test for over-identifying restrictions is that the instrumental variables are exogenous. The p-value of the output is 0.889 in this case. Therefore, the null hypothesis can not be rejected and it can be concluded that the instrumental variables are exogenous in this case.

The coefficient of the graduate education variable for the instrumental variable regression is 0.253 and is significant at 1 percent level. This effect is increased by 10.5 percentage points of the probability of promotion from partial effect of simple probit estimation and its effect is increased by about 70.9 percent. This indicates that there is downward bias due to endogeneity of the graduate education variable.

3. Results of Double Selection Model

The double selection model or correction model for both sample selection and endogeneity was estimated using inverse Mills ratios as an instrumental variable along

with other instrumental variables. This estimation was conducted based upon assumptions that there was sample selection bias and the graduate education variable was endogenous.

The instrumental variables for the simple probit model of the "STAY" equation are positive and significant except for "unemployment rate" as before. The F-statistics and p-value for the first stage regression are 329.1 and 0.000, respectively. This indicates that the four instrumental variables and an additional instrumental variable, which is the inverse Mills ratios from the simple probit model of the "STAY" equation, are significantly correlated with the endogenous variable graduate education. The partial R-squared between the endogenous variable, education variable, and the instrumental variables is 0.108. This indicates that the instrumental variables are not weak. The p-value of the test for over-identifying restrictions is 0.851 in this case. Therefore, the null hypothesis can not be rejected and it can be concluded that the instrumental variables are exogenous in this case as well.

The coefficient of the graduate education variable for the double selection model is 0.239 and is significant at the 1 percent level. This effect is 0.091 higher than the estimate obtained via probit estimation and its effect is increased by about 61.5 percent.[68] It indicates that there is downward bias due to both a combination of sample selection bias and endogeneity of the graduate education variable. Thus, it can be interpreted that an average officer with a graduate degree has a probability of promotion to Lieutenant Colonel that is 30.4 percent higher than an average officer without a graduate degree.[69]

D. CHAPTER SUMMARY

In this chapter, the results of estimations for the simple probit models, correction of sample selection bias, correction of endogeneity, and double selection models were

[68] The change of effect is calculated as: [Partial effect of baseline estimate (0.148) – coefficient of double selection estimate (0.239)] / Partial effect of baseline estimate (0.148) × 100%.

[69] The percentage change is calculated as: [Partial effect (0.239) / Probability of promotion (0.786)] × 100%.

presented. The effects of the graduate education variable are positive and significant for both the Lieutenant Colonel and Colonel samples. After the correction for sample selection bias, the effect of the graduate education variable on the promotion to Lieutenant Colonel is reduced by 59.5 percent from that of simple probit model, 0.148. After the correction for endogeneity, this effect is increased by 70.9 percent. Finally, the output of the double selection model indicates that this effect is increased by 61.5 percent after the correction for both sample selection bias and endogeneity.

V. SUMMARY, CONCLUSION AND RECOMMENDATIONS

A. SUMMARY AND CONCLUSIONS

This study investigates the effect of graduate education on the promotion of U.S. Army field grade officers and whether or not the effects of a graduate education are significantly different for each career field. Also, this thesis investigates if there are some other noteworthy influential factors in regards to promotion. The human capital theory and related policies of the U.S. Army were reviewed for detailed analysis. Furthermore, several previous studies were reviewed to acquire better methodologies and specifications of models for multivariate analysis. Based upon background study and literature review, a probit regression model and three correction models were built and methodologies for each model were introduced. The results of probit estimations were provided and three correction procedures were conducted to correct sample selection bias and endogeneity of the graduate education variable. It was found that the partial effects around the mean of a graduate education on the promotion to Lieutenant Colonel and Colonel are 0.148 and 0.132, respectively, under the assumption that no sample selection bias and endogeneity was present. For the promotion to Lieutenant Colonel, the Information Operations career field received the lowest effect from a graduate education and the "Others" category, which is the set of branches not included in any of the four career fields, received the highest effect from a graduate education. For the promotion to Colonel, the "Others" category received a higher effect from a graduate education than the Operations career field. The sample selection corrected estimator of a graduate education indicated that there as upward bias due to sample selection bias. The effect of a graduate education on the promotion to Lieutenant Colonel was reduced by 59.5 percent after the correction procedure. The result of the instrumental variable regression for endogeneity indicated that there was downward bias due to endogeneity and this effect was increased by 70.9 percent after the correction procedure. Finally, the results of the double selection model indicated that there was combined downward bias due to both sample selection bias and

endogeneity. The effect of the graduate education variable was increased by 61.5 percent after the correction procedure. Therefore, an average officer with a graduate degree has a probability of promotion to Lieutenant Colonel 30.4 percent higher than an average officer without a graduate degree.

From the results, one can conclude that there is a statistically significant and positive effect of graduate education on the promotion to both Lieutenant Colonel and Colonel. This is consistent with human capital theory and most previous studies. This magnitude of effect is larger than that of the USAF and USN when compared to previous studies. The effect of a graduate education in regards to the USMC, however, is similar to that of the U.S. Army. Additionally, the promotion to Colonel receives a smaller effect from a graduate education than promotion to Lieutenant Colonel. This might be because of the fact that officers who are about to be reviewed for the promotion to Colonel possess approximately same levels of cognitive abilities and experiences through the screening process of several promotion selection boards. It can be also concluded that there are significant differences among career fields regarding effects of a graduate education on the promotion to Lieutenant Colonel. The "white" race and sources of commission such as the USMA and ROTC have significant and positive effects on the promotion to Lieutenant Colonel. Entry age has a significant and negative effect on the promotion to Lieutenant Colonel. For the promotion to Colonel, some demographic factors such as divorced with children and number of dependents have significant and negative effects. The variable "married with children" has a significant and positive effect on the promotion to Colonel.

It was found from the results of three correction models that there were some upward or downward biases of the graduate education variable due to sample selection and endogeneity. It can be concluded that there is combined downward bias of the graduate education variable for the U.S. Army data set due to sample selection and endogeneity. Although the officers in the selected sample, who are more likely promotable to Lieutenant Colonel, have stayed until promotion selection and earned a graduate degree, some unobserved factors more strongly affect the choice or decision of

having a graduate degree so that it induces some best-performing officers, who will more likely be promoted to Lieutenant Colonel, not to choose to earn a graduate degree. In other words, some best-performing officers are more focused on their career management in the field and less focused on the enhancement of potential productivity through the graduate education program in the U.S. Army. This fact might cause the downward bias of the graduate education variable. In this study, it was found that the effect of the graduate education variable was increased by 61.5 percent after the correction for both sample selection and endogeneity.

Overall, results of this study are consistent with investments in human capital of human capital theory. Downward bias in respect to self-selection issue of graduate education is consistent with USMC study of Branigan. But it is inconsistent with studies of Bowman and Mehay, and Blackburn and Neumark. There can be possible explanation that characteristic of officers in USMC or U.S. Army are different that of USN, USAF, or employees in private sectors. Officers in USMC or U.S. Army are needed to highly focus on performance of practical managerial tasks and excellent leadership in operation fields. If they want to be promoted general officer level, they should have more experience in operation fields rather than to attend and finish a graduate education. Officers in USN, USAF and employees in private sectors, however, generally focus more on performance of technical and intellectual tasks due to their missions and task environments. To enhance their ability and be informed for recent change of technologies and knowledge, they are often needed to attend an advanced education. Therefore, opportunity costs for attending a graduate education of U.S. Army or USMC officers are larger than that of USN, USAF, and employees in private sector. This kind of differences of characteristics may make inconsistency of selection corrected estimators.

The effects of graduate education from military are generally bigger than that of private sectors. One of possible reasons is that many individuals in private sectors were already screened by a graduate education in respect to signaling at entries of certain firms. Nowadays, many candidates for employees in private sectors earn graduate degrees before they enter certain firms. Thus, private firm initially screen employees by

implementing signaling effect of a graduate education and most hired employees with a graduate education are assigned to position so that they can perform and receive compensation which is equivalent for their education levels. Therefore, it is less likely to observe increased productivities of employees who possess a graduate degree in most case of private sectors. In the military, however, almost every officer enters military without a graduate degree except for officers in medical or judicial corps. Thus, there is no role of a graduate education as a signaling tool at the entry. Since officers obtain their graduate degree within service time, it is possible to observe increased productivities of individual officers in the military circumstance. Therefore, I argue that the effects of graduate education for military officers are generally bigger than that of employees in private sector.

B. LIMITATIONS

There exist some limitations for this study. The results of the three correction models for the Colonel sample and for each of the career fields are inconclusive due to the small sample size, and therefore the results are not displayed or discussed in this study. Some other cognitive factors such as grade point average associated with one's undergraduate degree or type of undergraduate and graduate degree are not available for this study. Also, significant affective factors such as evaluation data are not available for this study. The U.S. Army has changed its OPMD design in 2005 and corresponding data set is not available for this analysis. Lastly, this study did not distinguish the source and type of an officer's graduate education.

C. RECOMMENDATIONS FOR FURTHER STUDY

Further studies could utilize the findings of this and previous studies for cost-effective or cost-benefit analyses regarding a graduate education program. Additionally, the unbiased effect of a graduate education on the promotion to Colonel and each career field with sufficient sample size could be investigated. Also, the findings of this thesis could be helpful for a detailed cost-effective analysis by distinguishing the source and type of graduate education variable. With sufficient data elements such as cognitive and

affective factors regarding promotion, a robust and more reliable multivariate analysis could be conducted as well. Further study can also focus on the new implemented OPMD design of the U.S. Army. When sufficient data sets and documents are available, a detailed analysis regarding three newly established career fields such as MFE, OS, and FS can be conducted.

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APPENDIX A. ESTIMATION RESULTS BY CAREER FIELD

Table 13. Estimation Results of Lieutenant Colonel Sample by Career Field (Partial Effects)

	Operations	Institutional Support	Information Operations	Operational Support	Others
Graduate education	0.144 (0.014)***	0.070 (0.054)	0.117 (0.057)**	0.156 (0.063)**	0.216 (0.035)***
Female	0.002 (0.022)	-0.009 (0.085)	0.028 (0.093)	-0.004 (0.065)	0.041 (0.026)
White	0.132 (0.049)***	0.164 (0.133)	0.090 (0.216)	-0.015 (0.115)	-0.052 (0.063)
Black	0.071 (0.039)*	0.030 (0.089)	0.028 (0.154)	0.048 (0.101)	-0.072 (0.115)
USMA	0.037 (0.018)**	0.051 (0.057)	0.056 (0.053)	0.029 (0.040)	0.011 (0.034)
ROTC	0.037 (0.015)**	0.106 (0.045)**	0.077 (0.052)	0.028 (0.037)	0.082 (0.025)***
OCS	0.035 (0.076)				
Married	0.028 (0.042)	0.131 (0.155)	0.082 (0.160)	0.148 (0.102)	0.071 (0.070)
Married with children	-0.002 (0.039)	0.019 (0.183)	0.121 (0.043)***	-0.038 (0.103)	0.027 (0.052)
Divorced with children	-0.025 (0.046)	0.098 (0.076)	0.017 (0.129)	0.077 (0.055)	0.057 (0.053)
Prior Enlistment	-0.040 (0.021)*	0.027 (0.061)	0.042 (0.065)	0.028 (0.046)	0.071 (0.026)***
Entry Age	-0.014 (0.003)***	0.003 (0.013)	0.006 (0.013)	-0.012 (0.009)	-0.012 (0.004)***
Number of Dependents	0.022 (0.019)	-0.016 (0.056)	-0.150 (0.072)**	0.022 (0.039)	-0.010 (0.022)
Cohort82	0.061 (0.017)***	0.092 (0.042)**	0.025 (0.074)	-0.164 (0.101)	0.008 (0.042)
Cohort83	0.103 (0.017)***	0.082 (0.044)*	-0.105 (0.110)	-0.276 (0.113)**	-0.003 (0.045)
Cohort84	0.146 (0.014)***	0.091 (0.043)**	0.125 (0.048)***	-0.149 (0.080)*	0.014 (0.036)
Cohort85	0.196 (0.016)***	0.061 (0.051)	0.043 (0.066)	-0.075 (0.081)	-0.008 (0.041)

Observations	4308	308	205	458	881
Log likelihood	-2220.901	-118.340	-75.366	-166.370	-330.637
Pseudo R-squared	.0721	.0761	.1346	.0743	.1115

Standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 14. Estimation Results of Colonel Sample by Career Field (Partial Effects)

	Operations	Institutional Support	Information Operations	Operational Support	Others
Graduate education	0.130 (0.048)***	-0.209 (0.292)	0.026 (0.289)	0.050 (0.233)	0.290 (0.119)**
Female	0.135 (0.068)**	0.346 (0.318)	-0.260 (0.470)	-0.080 (0.231)	-0.017 (0.122)
White	-0.001 (0.117)	0.709 (0.227)***	-0.862 (0.065)***	-0.744 (0.096)***	0.688 (0.054)***
Black	0.060 (0.139)	0.868 (0.158)***	-0.731 (0.084)***	-0.599 (0.130)***	0.740 (0.054)***
USMA	0.061 (0.051)	0.322 (0.218)	-0.127 (0.224)	-0.163 (0.147)	0.164 (0.122)
ROTC	-0.013 (0.046)	0.477 (0.217)**	-0.262 (0.232)	-0.052 (0.156)	0.045 (0.104)
Married	0.105 (0.048)**	-0.105 (0.233)		0.168 (0.155)	
Married with children	0.258 (0.102)**			0.046 (0.267)	0.413 (0.214)*
Divorced with children			-0.518 (0.214)**		-0.056 (0.103)
Prior Enlistment	0.022 (0.057)	-0.310 (0.145)**	0.097 (0.352)	0.295 (0.171)*	-0.138 (0.108)
Entry Age	-0.018 (0.013)	0.086 (0.066)	0.111 (0.056)**	0.018 (0.060)	0.014 (0.024)
Number of Dependents	-0.138 (0.072)*		0.509 (0.465)		-0.159 (0.161)
Cohort82	-0.221 (0.037)***	-0.294 (0.124)**	-0.346 (0.195)*	-0.492 (0.098)***	-0.246 (0.083)***
Observations	765	71	42	96	156
Log likelihood	-499.547	-37.096	-21.907	-53.337	-94.458
Pseudo R-squared	.0568	.2329	.2425	.1893	.1265

Standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

APPENDIX B. ESTIMATION RESULTS OF CORRECTION MODELS FOR LIEUTENANT COLONEL SAMPLE

Table 15. Estimation Results of Correction Models

	Correction of sample selection (MLE estimation)		**Correction of endogeneity**	**Double selection**
Dependent variable:	Promoted Lieutenant Colonel	STAY	Promoted Lieutenant Colonel	Promoted Lieutenant Colonel
	Independent variables			
Graduate education	0.250 [0.061] (0.104)**	1.546 (0.022)***	0.242 (0.088)***	0.209 (0.097)**
Operations	-0.202 (0.062)***	-0.553 (0.047)***	-0.045 (0.023)**	-0.071 (0.017)***
Institutional Support	-0.186 (0.116)	1.328 (0.128)***	-0.008 (0.025)	0.026 (0.047)
Information Operations	-0.156 (0.137)	1.435 (0.146)***	0.013 (0.030)	0.048 (0.055)
Operational Support	-0.189 (0.101)*	1.369 (0.124)***	-0.029 (0.022)	0.013 (0.041)
Female	0.065 (0.061)	-0.372 (0.033)***	0.001 (0.018)	-0.002 (0.019)
White	0.309 (0.116)***	0.124 (0.066)*	0.097 (0.040)**	0.102 (0.039)***
Black	0.182 (0.129)	0.189 (0.072)***	0.076 (0.043)*	0.080 (0.044)*
USMA	0.105 (0.054)*	0.011 (0.044)	0.016 (0.021)	0.031 (0.015)**
ROTC	0.155 (0.046)***	0.112 (0.026)***	0.050 (0.013)***	0.057 (0.014)***
OCS	0.319 (0.257)	0.078 (0.119)	0.096 (0.055)*	0.095 (0.054)*
Married	0.117 (0.109)	0.268 (0.053)***	0.030 (0.030)	0.043 (0.031)
Married with children	0.033 (0.106)	-0.081 (0.061)	0.010 (0.031)	0.001 (0.031)
Divorced with children	0.040 (0.117)	-0.088 (0.058)	-0.006 (0.033)	-0.011 (0.034)
Prior Enlistment	-0.024 (0.055)	-0.181 (0.030)***	-0.020 (0.016)	-0.026 (0.018)
Entry Age	-0.038	-0.029	-0.012	-0.014

	(0.009)***	(0.005)***	(0.003)***	(0.003)***
Number of	0.032	0.015	0.006	0.007
Dependents	(0.048)	(0.027)	(0.013)	(0.013)
Cohort82	0.219	-0.117	0.061	0.060
	(0.057)***	(0.038)***	(0.018)***	(0.018)***
Cohort83	0.308	-0.128	0.088	0.083
	(0.064)***	(0.051)**	(0.019)***	(0.020)***
Cohort84	0.480	-0.133	0.135	0.128
	(0.053)***	(0.069)*	(0.015)***	(0.016)***
Cohort85	0.618	-0.118	0.166	0.160
	(0.065)***	(0.087)	(0.017)***	(0.018)***
Member of		-0.624		
Special Forces		(0.060)***		
Inverse Mills				0.067
Ratio				(0.070)
Unemployment		0.022		
Rate		(0.045)		
Military Spouse		0.637		
		(0.034)***		
Constant	1.104	-0.409	0.710	0.704
	(0.287)***	(0.352)	(0.105)***	(0.111)***
Observations	25839	25839	6168	6168

Standard errors in parentheses
Partial effect in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%

APPENDIX C. LIST OF ACRONYM

ADSOs	Active Duty Service Obligations
AFSC	Air Force Specialty Code
ASVAB	Armed Services Vocational Aptitude Battery
CCC	Captains Career Course
CFDB	Career Field Designation Board
CNA	Center for Naval Analyses
DMDC	Defense Manpower Data Center
DoD	Department of Defense
DPOG	DoD Primary Occupation Code
FA	Functional Areas
FS	Force Sustainment
GCT	General Classification Test
GPA	Grade Point Average
HQDA	Headquarters, Department of Army
HRC	Human Resource Command
IV	Instrumental Variable
LR Test	Likelihood Ratio Test
MFE	Maneuver, Fires and Effects
MLE	Maximum Likelihood Estimation
MOS	Military Occupational Specialty
NFO's	Naval Flight Officers
NLSY79	National Longitudinal Survey Youth 1979
OCS	Officer Candidate School
OES	Officer Education System
OLS	Ordinary Least-Squares
OPMD	Officer Personnel Management Directorate
OPMS	Officers Personnel Management System
OS	Operations Support
PMRS	Performance Management and Recognition System
ROTC	Reserve Officers' Training Corps
SWO	Surface Warfare Officers
TIG	Time in Grade
TIS	Time in Service
USNA	U.S. Naval Academy
2SLS	Two-Stage Least Squares

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